

4 (red) corresponded to high level of severity. For our analysis we combined zones 1 and 2 into a “low severity” class whereas zones 3 and 4 were combined into a “high severity” class. Our goal was to build predictive rules which allow forecasting of the severity class one day ahead of time using methods of artificial intelligence. We used dependent variables from a day N to predict the severity class on the day N + 1. Overall, 7001 records collected from 26 asthma patients were used in this analysis. Classification and Regression Trees (CART) algorithm was employed to develop three predictive models. Model I utilized all predictive variables, model II employed only 3 variables identified by CART as the most powerful predictors, and model III used only asthma symptom variables. **RESULTS:** The CART algorithm prioritized three predictor variables (normalized number of puffs of quick relief inhaler, normalized PEF, and asthma symptom score) based on their level of influence on the “asthma severity class” variable. The resulting forecast rules yielded good overall prediction success rates from both the learning (87.2%; 98.6%; 96.2%) and testing (86%; 96.5%; 95.2%) samples of models I, II, III respectively. Moreover, it generated 63 decision rules accurately characterizing both “low” and “high” severity classes. **CONCLUSIONS:** CART algorithms showed acceptable accuracy in forecasting asthma exacerbations.

PAS8

#### IMPROVING ASTHMA SELF-MANAGEMENT AND PATIENT OUTCOMES USING AN AUTOMATED PROGRAM

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**OBJECTIVE:** The high prevalence of asthma has emerged as a major public health issue. It has been shown that patient education on self-management is an essential and effective component of chronic illness management. The objective of the current study was to report on outcomes associated with implementation of an automated patient self-management system, ALERTS®, in a primary care group practice—ProHealth Physicians (PHP). **METHODS:** A pre/post design was employed. Patients were identified using PHP's billing database. ALERTS® was accessed via the Internet or via a toll-free number. Patients were given real-time feedback regarding their symptom zone and actions to take based on their Asthma Action Plan. ALERTS® made reports on patients' peak flow meter (PFM) readings available to patients and their providers. Outcomes assessed included unscheduled outpatient visits, emergency room (ER) visits, days lost from work/school, medication prescriptions, and number of outpatient procedures. Comparisons of pre/post intervention outcomes were calculated using the paired t-test, McNemar's test for dichotomous data and Chi-Square as a comparison of proportions. **RESULTS:** Seventy-four participants were enrolled. Patients demonstrated reductions in the number of unscheduled office visits ( $p = 0.033$ ) when comparing these prior to and after ALERTS® use. Additionally, 55.9% (33/59) of participants saw an increase in their personal best PFM measurement ( $p < 0.001$ ); 100% (6/6) of participants under the age of 18 saw an increase in this parameter ( $p = 0.027$ ). Furthermore, participants answering the question reported missing less school/work due to their asthma ( $p = 0.026$ ). There was also a trend towards reduction in limited physical activity, ER visits and prednisone use. **CONCLUSION:** ALERTS® was successfully implemented in a multi-site group practice, proving to be a useful program for improving care of chronic asthmatic patients.

#### ASTHMA—Methods and Concepts

PAS9

#### THE PERFORMANCE OF BOOTSTRAPPING IN DISCRETE CHOICE MODELS

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**OBJECTIVE:** Discrete choice models are widely used in pharmacoeconomics. If correctly applied, bootstrapping is a useful tool for these models because small sample distributions of the dependent variables are not known. In this paper, we will show how to apply bootstrapping to have consistent and efficient estimators under discrete choice models. **METHOD:** Four common bootstrapping techniques were analyzed: paired, non-parametric, parametric, and wild bootstrapping. The extension of parametric bootstrapping for linear regression to parametric discrete choice models is presented: Let  $U$  be the probability that the binary dependent variable  $y = 1$ . Then for each application we choose  $y^*$ , which is the new independent variable for each bootstrap, from Bernoulli distribution with probability of success given by  $U$ . **RESULTS:** The Market Scan® private insurance database was used in this study. The analytic sample comprised 36,341 individuals with asthma whose healthcare was provided under a variety of fee-for-service (FFS), fully capitated, and partially capitated health plans. We estimated hospitalization for FFS and non-FFS asthma patients. Logit models were selected depending on the distribution of the dependent variable. The Pearson chi-square goodness of fit test ( $p = 0.3742$ ) and the Hosmer and Lemeshow test ( $p = 0.2904$ ) suggested that the model fit well. Treatment patterns had no significant effect on hospitalization after controlling for demographic and clinical factors. The illness severity of the patient (proxied by the number of three-digit ICD-9 codes), however, had a positive and significant effect on hospitalization. We would not have seen this significant effect if we had chosen paired, non-parametric, or wild bootstrapping as a way to bootstrap standard errors. **CONCLUSION:** Despite the obvious benefit of bootstrapping in discrete choice models, the method should not be used blindly. Once the model is estimated under parametric assumptions, as in logit or probit models, deviations of the assumptions for bootstrapping will yield inefficient estimators.

PAS10

#### A SYSTEMATIC OVERVIEW OF THE MEASUREMENT PROPERTIES OF THE ST. GEORGE'S RESPIRATORY QUESTIONNAIRE IN ASTHMA

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**OBJECTIVES:** The St. George's Respiratory Questionnaire (SGRQ) is a disease-specific instrument used to measure health-related quality of life (HRQoL) in patients with asthma. It is a 76-item questionnaire comprised of three domains: symptoms, activities, and impact. We conducted a systematic review to determine the psychometric measurement properties. **METHODS:** We used the search terms “St. George's Respiratory Questionnaire” and “St. George's Respiratory Questionnaire and asthma”. All published papers and abstracts were reviewed and assessed using MEDLINE 1966–2005, April Week 2 and OVID full-text via the University of Southern California library database and Google Scholar. Citations for all abstracts and articles citing the first validation study were identified using the Science Citation Index. Inclusion criteria included clinical trials and observational studies reporting measurement properties in a

population with asthma. **RESULTS:** We found 18 articles that met the inclusion criteria; three were validation studies and the remaining were observational studies or clinical trials. All three domains of the SGRQ are internally consistent and reliable with ICC of at least 0.70 for individual domains and greater than 0.90 for total score. Convergence and discriminate validity were seen with two of three domains and dyspnea grade, six-minute walk distance, and other HRQoL instruments. Face and content validity were demonstrated. SGRQ was able to discriminate between patients with varying levels of symptoms, FEV1, self-reported healthcare utilization services, asthma control problems, and HRQoL. Responsiveness to change, however, is not well-established for SGRQ despite a reported minimally important difference of 3.9-unit change, which may be due partly to a paucity of studies using SGRQ in this population. **CONCLUSIONS:** Our findings suggest SGRQ has face, content, and construct validity. It is able to discriminate between different groups of asthma patients, and may be useful in facilitating asthma resource allocation. Further research is needed to determine its responsiveness to change.

## PAS11

#### PROPSENSITY SCORE MATCHING WITH MORE THAN TWO CATEGORIES

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**OBJECTIVE:** We applied the extension of propensity score methodology that allows for estimation of average causal effects with multi-valued treatment. **METHODS:** The methodology requires three steps: 1. Estimating propensity score with multinomial or nested logit 2. Estimating the conditional expectation and 3. estimate average respond treatment by calculating average of conditional expectation averaged over the distribution of the pre-treatment variables. **RESULTS:** The Market Scan private insurance data base was used in this study which based upon asthma individuals whose health care was provided under a variety of fee-for-service (FFS), fully capitated and partially capitated health plans, including exclusive provider organizations, indemnity plans. Treatment is divided into three categories: a) controller only; b) reliver only; and c) reliever and controller. These three categories is matched with control group using multinomial logit. Pre-period demographic and clinical factors are used as a covariate. Conditional expectations are calculated and applied as a weight to estimate average treatment effect among asthma patients. Reliever and Controller patients have the highest treatment effect whereas controller only patients have the lowest effect. **CONCLUSION:** Multi-valued treatment is common in pharmacoecoeonomical research and extension of propensity score matching to cover multi-valued treatment is straightforward and easy to apply.

#### ASTHMA—Patient Reported Outcomes

## PAS12

#### TREATMENT PERSISTENCE AND COMPLIANCE WITH MEDICATIONS FOR ASTHMA AND CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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**OBJECTIVE:** To assess the patterns of persistence with various classes of inhaled medications (i.e., beta agonist, anticholinergic, and glucocorticoid) medications used to treat asthma and chronic obstructive pulmonary disease (COPD). **METHODS:**

Pharmacy claims data were analyzed for persistence with inhaled treatment (time to discontinuation) using a 60-day gap to define discontinuation. Compliance, defined as the percentage of days with doses available divided by days to last refill, also was assessed. Patients were grouped as naïve (no inhaled medication in the previous year) or experienced (previous or current treatment), and by age (18–65, 65+ years). Medications included: ipratropium, ipratropium + salbutamol, formoterol, formoterol + budesonide, salmeterol, salmeterol + fluticasone, and tiotropium. **RESULTS:** The database included 31,368 patients prescribed one of these medications (4,888 naïve, 26,480 experienced). Based on a 60-day lapse in refill, only 15–63% of patients continued on the index drug for more than 6 months, further decreasing to 7–53% at 12 months, and 5–47% at 18 months. At 12 months, patients taking tiotropium had significantly longer persistence rates compared to that for other drugs (53% versus 7–30%, all  $p < 0.0001$ ), and fewer switches to alternative medications. Naïve patients had significantly shorter treatment persistence than experienced patients for all drugs (all  $p < 0.0001$ ), including tiotropium (27% versus 55%,  $p < 0.0001$ ). Compliance rates were similar for all drugs (i.e., 76%–94%) but highest for tiotropium. **CONCLUSIONS:** These data demonstrated that 1) persistence with inhaled treatment for asthma and COPD was low overall (despite the generous 60-day allowance to refill), but patients stayed on treatment with tiotropium significantly longer than with other medications, and 2) patients naïve to these classes of inhaled treatment had shorter treatment persistence than experienced patients.

## PAS13

#### ASSOCIATION OF MEDICATION ADHERENCE WITH WORKPLACE PRODUCTIVITY AND HEALTH-RELATED QUALITY OF LIFE IN PATIENTS WITH ASTHMA

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Asthma is a chronic inflammatory disorder of the lungs and has a significant impact on morbidity, mortality, and health-related quality of life (HRQL). Asthma also impacts indirect costs resulting from losses in workplace productivity. **OBJECTIVE:** To examine the association of medication adherence with workplace productivity and HRQL in patients with asthma in a state health insurance program. **METHODS:** The diagnosis of asthma was identified from medical claims data of state employees between 18 and 65 years of age who obtained healthcare benefits from a state health insurance program from July 2001 through June 2003. A three-part survey was mailed to these patients to measure HRQL, workplace productivity, (absenteeism [time lost from work] and presenteeism [reduced productivity at work]), and self-reported medication adherence. The survey consisted of the St. George's Respiratory Questionnaire, the Workplace Productivity Short Inventory, and the Morisky Adherence Scale. Productivity losses were translated into dollar values by using previously published metrics (employer perspective). The association between self-reported medication adherence and HRQL and productivity was measured using multivariate regression analyses. **RESULTS:** The response rate was 25.1% (385/1493). The mean HRQL total summary score was  $33.2 \pm 19.9$  units, with the symptoms domain having the worst HRQL scores ( $49.3 \pm 21.4$  units), followed by the activity ( $39.6 \pm 26.6$ ) and impacts ( $24.6 \pm 19.1$ ) domains. 39% of the participants reported themselves as "high" adherent, 19% reported themselves as "medium" adherent, and 42% as "low" adherent. Asthma resulted in productivity losses of  $\$597 \pm \$1024$  (absenteeism)